

Pultrusion of Low Maintenance Composite Military Structures

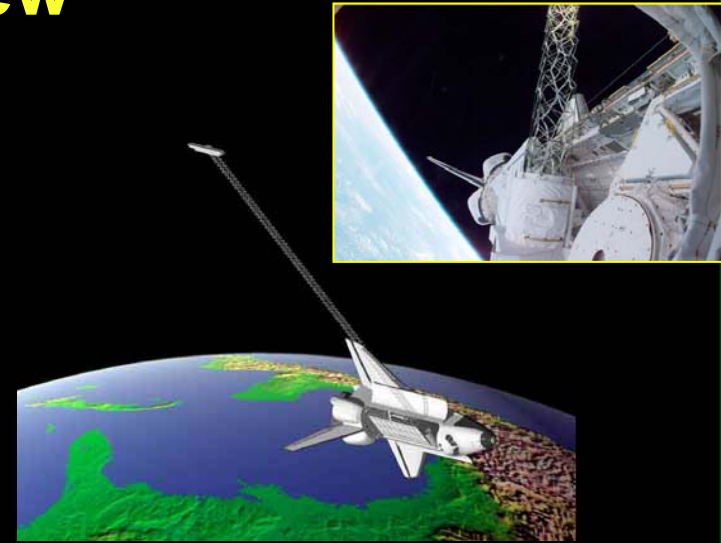
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KaZaK Composites Inc.
Woburn, MA & Yemassee, SC

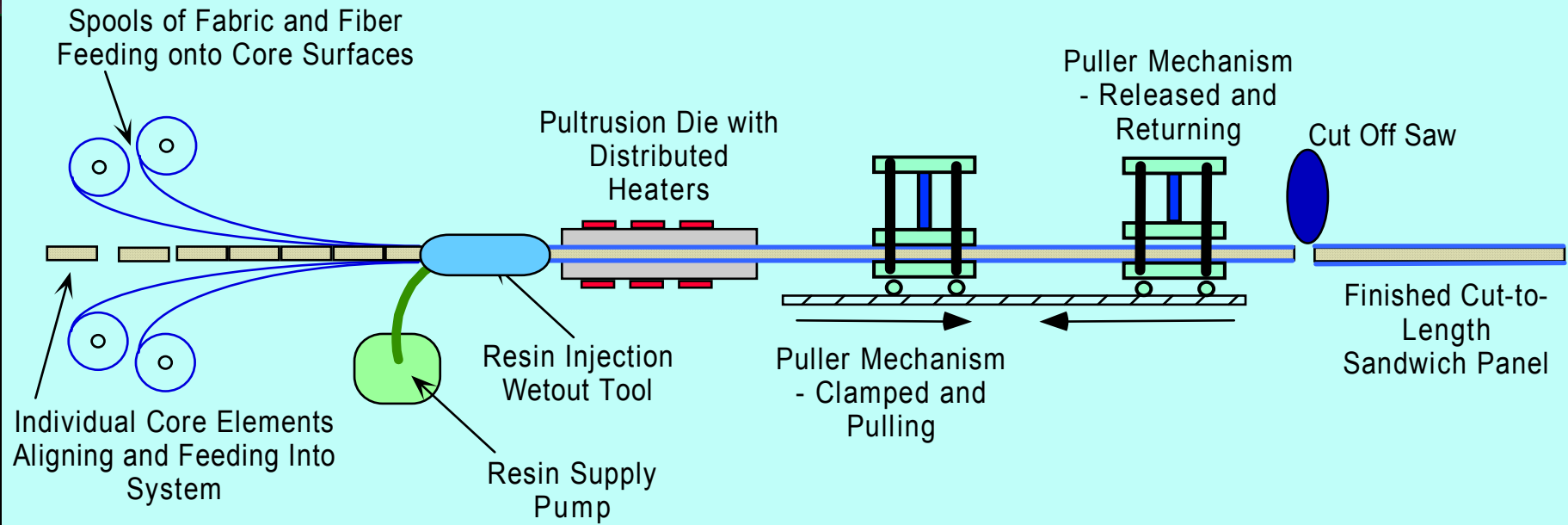


KaZaK Composites Overview

- Founded 1992
- Focus - High Performance Composite Structures
 - » low cost automated manufacturing
 - » high value-added engineering
- Two Locations
 - » Woburn, MA – design, engineering, prototype fab
 - » Yemassee, SC – large pultrusion & production
- KCI Operates World's Largest Pultrusion Equipment
 - » Filament winding, braiding
 - » VARTM, press, oven cure
- Outstanding Engineering Team
 - » 15 advanced degree engineers

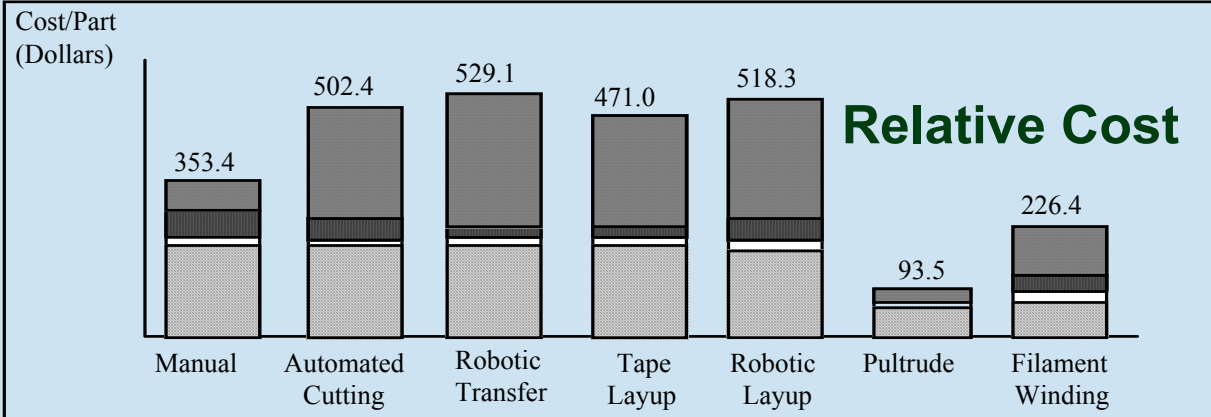
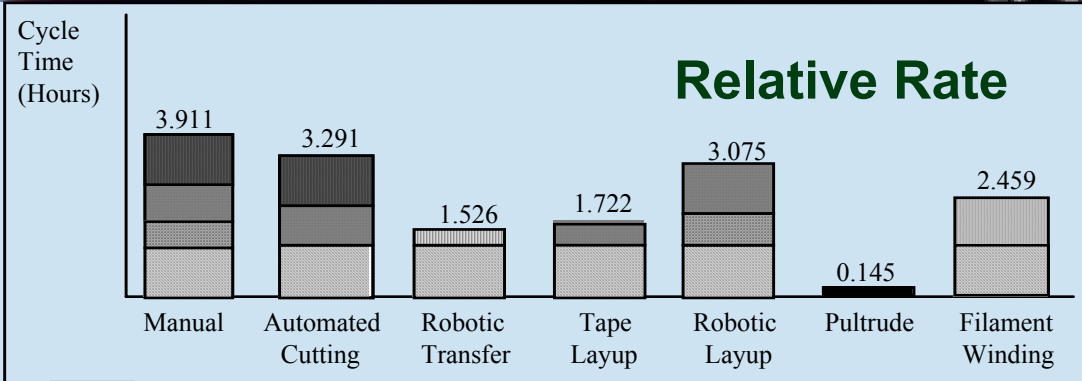


Pultrusion Manufacturing Overview



- Composites offer potential for low maintenance cost but acquisition cost must compete with metal
 - Corrosion resistance
 - No painting
 - Impact damage resistance
- Pultrusion provides virtually hands-off manufacturing automation
→ labor and tooling become a small fraction of material cost

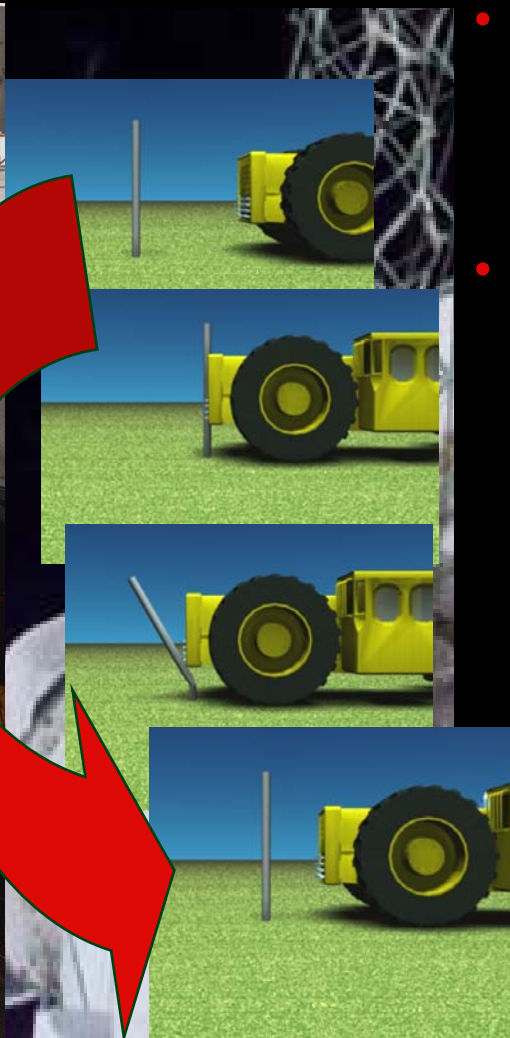
Pultrusion Manufacturing Overview – Why Pultrusion?



- Pultrusion Compared to Other Processes for 2 x 2 Foot Square Stiffened Carbon/Epoxy Panel

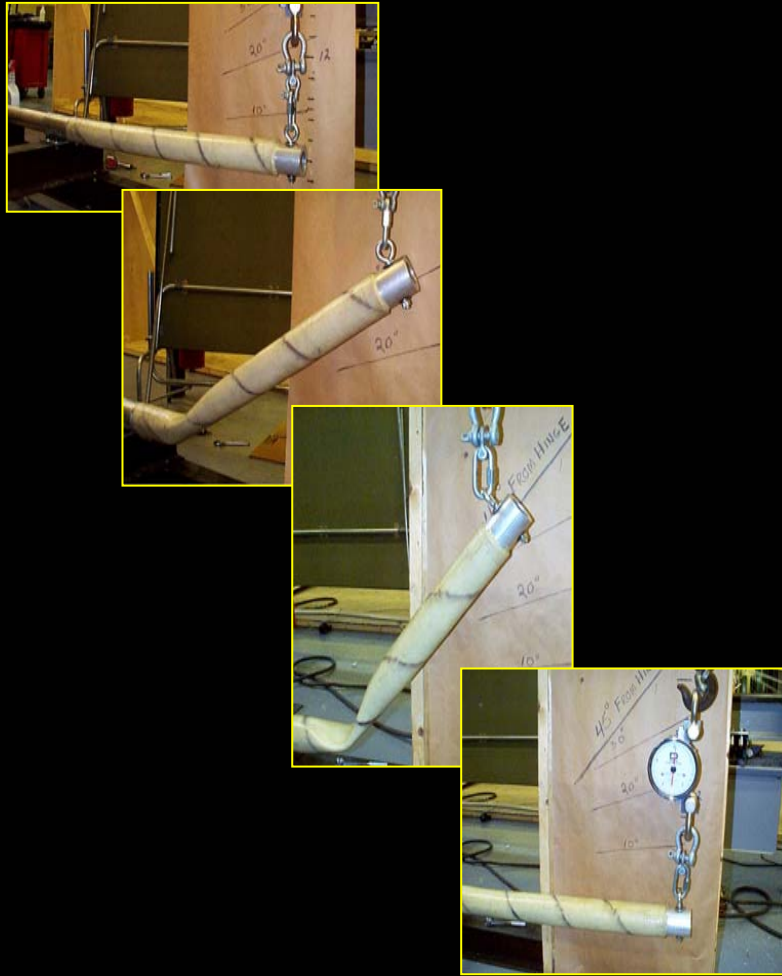
Ref - Krolewski, S., and Gutowski, "Effect of the Advanced Composite Fabrication Process on Part Cost," 18th *International SAMPE Technical Conference*

Navy Application - Damage Resistant Pultruded Composite Polyurethane Stanchions



- **Problem** - Impact by deck equipment bends steel & incapacitates CVN elevators
- **Solution** - Polyurethane composite stanchions
 - » carry same 300 lb tip load as current steel stanchions
 - » return to vertical after 45 degree bend
 - » Acquisition cost less than alternative stainless steel
 - » No painting
 - » Better RCS

Zero Maintenance Pultruded Composite Polyurethane Stanchions



First Non-Carrier Implementations

Modular Causeway System
Roll-On Roll-Off Discharge Platform
Modular Warping Tug

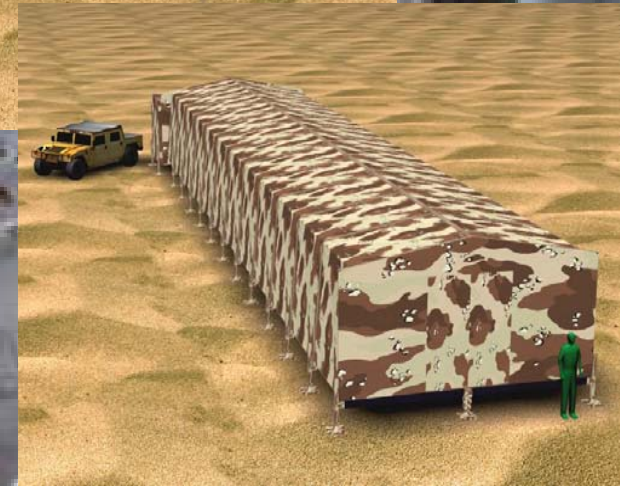
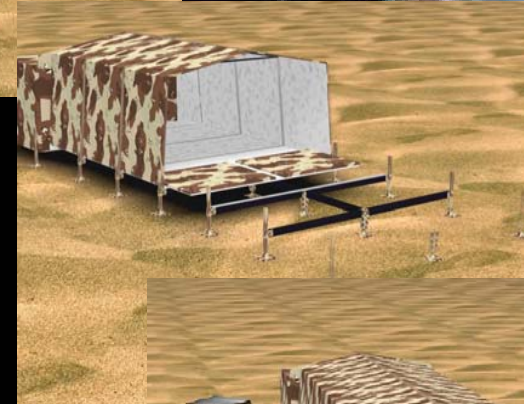
Air Force Application - Composite Aircraft Maintenance Stand

- Greatly reduces maintenance costs
 - » No corrosion
 - » no hydraulics
 - » no painting
- Replaces 4 stands in AF inventory
- Greatly reduces logistics footprint – packaging improvement

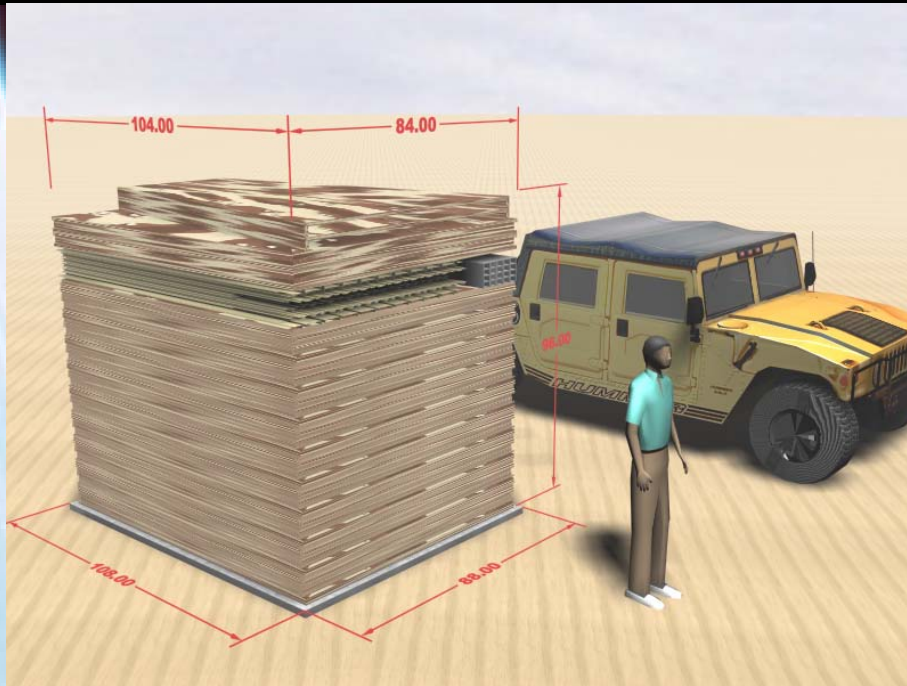


Army Application - High Expansion Ratio Tactical Shelters

- Reduced Cost vs Tents for Troop Housing
- Ships in 20x8x8 ISO container
- Expands 12:1 to 96' x 19' rigid shelter
- 50% improvement in thermal insulation
- Greatly improves living conditions
- Each: ~5,000 ft² of pultruded composite sandwich panel @ ~\$15K for panels



Next Generation Tactical Shelter Derivative - 463L Palletized Variation

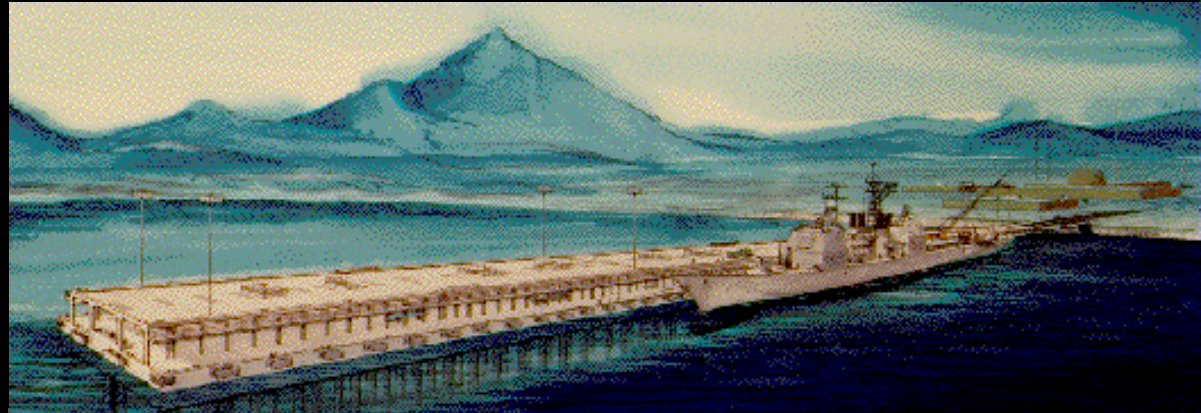


- Resized for optimized air transport
- Better cost & weight than ISO-packaged variation
- Low maintenance advantages of composites
- Configurable for enclosed vehicle maintenance



Navy Application - Low Maintenance Piers & Bridge Decks

- Panels 10+' wide
- Unlimited length
- Cost approaches raw materials
- Throughput 20,000 pounds of finished composite structure *per hour*



Pultrusion of Large Ship Structures

Current Naval Construction – DDG 51

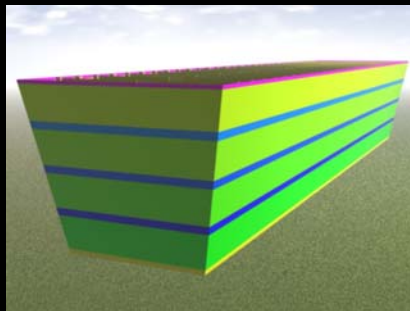
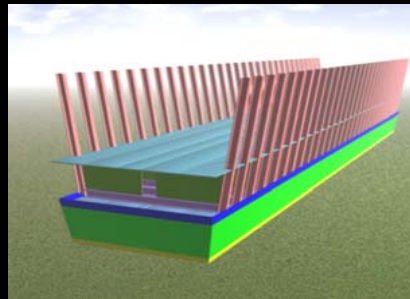
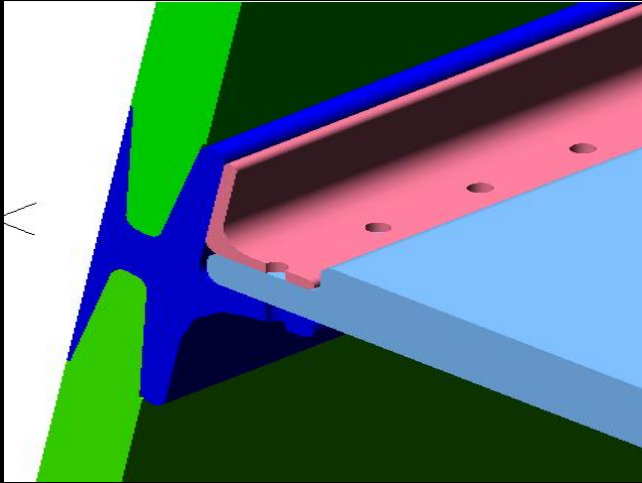
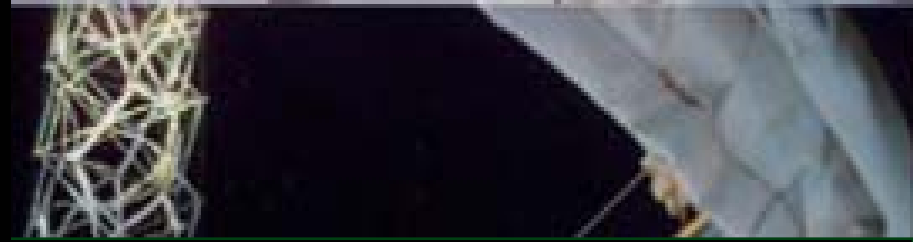


- Surface Combatants will lead development of very large composite applications
 - » Weight
 - » Corrosion resistance
 - » RCS advantages
- Next-Gen slab-sided low-RCS structures ideal for
 - » Composites
 - » Very Large Pultrusion



Next Generation DDX

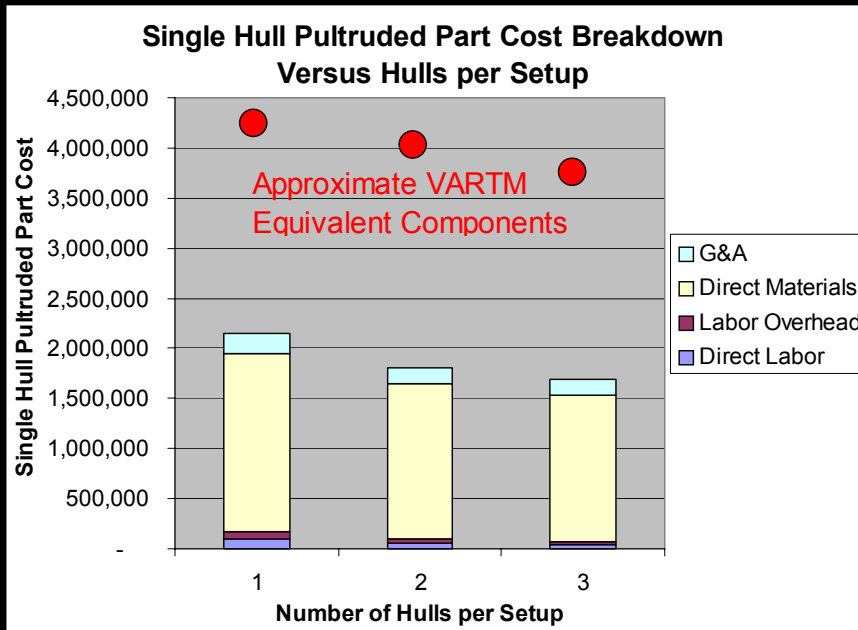
Pultrusion Versus VARTM for DDX Deckhouse



- Pultrusion of large panels and joints could revolutionize ship construction and cost-effectively provide the low maintenance benefits of composites



Pultruded DDX Composite Deckhouse

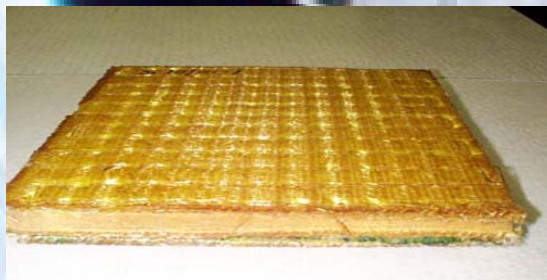
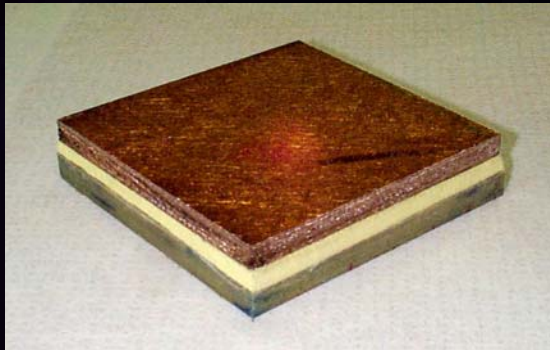


**Composite Pultruded
Deckhouse Saves 50% Over
VARTM DDX Structure**



**Testing
Pultrudable
Joint Detail**

Marine Corps Application – Pultruded Composite Armor

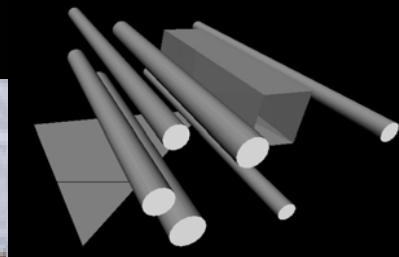


- Multi-Material Approach optimizes performance
- Layers to blunt, capture, prevent fire
- Incorporation of ceramic inserts possible
- Multi-hit capability



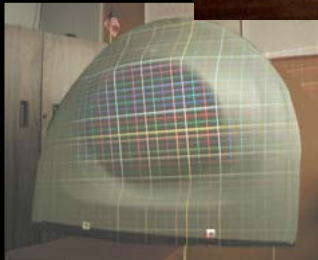
Pultruded Composite CVN Joiner Panel System

- Pultruded system reduces cost and weight of joiner panel system
- Address components individually and as a system
 - » Pultruded deck coaming
 - » Pultruded composite panel
 - ~ Phenolic foam and skinned panel
 - ~ Commercial phenolic foams
 - ~ KCI-developed phenolic core
 - » Curtain plate materials and installation system



Other KCI Composite Developments Focused on Cost and Weight Reduction

Finished Composite Tool

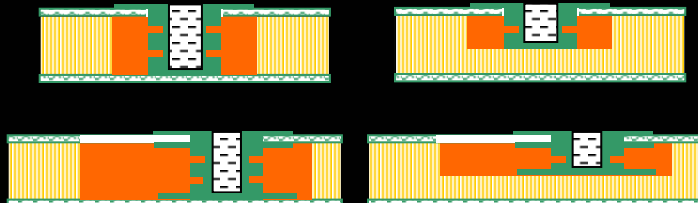


Low Cost, Low CTE Composite Tooling

Original Part Photographs



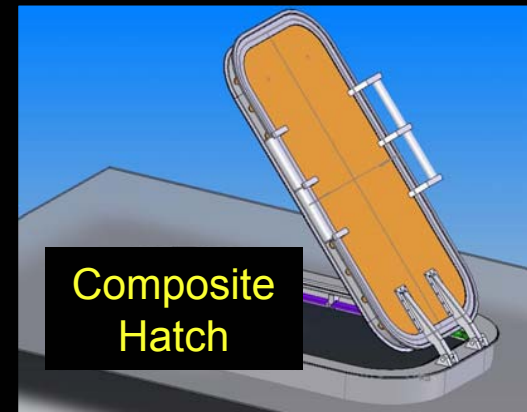
Damage Resistant Replacement for Lighter Hull Bottoms



Composite DDG Panel Attachments



Replacement for Honeycomb Core



Composite Hatch

Conclusions

- Composites can be cost-effectively applied to military applications to reduce maintenance cost
 - » Corrosion
 - » Painting
 - » Impact damage
- Properly designed pultruded composites allow acquisition cost of composites to compete with metal